DOCUMENT RESUME

ED 183 211 IR 008 162

AUTHOR Southworth, Raymond: Cape, Robert
TITLE Teleprocessing: Use by Virginia Institutions of Higher Education. Telecommunications Study Commission, Working Paper No. 15.
INSTITUTION Virginia State Telecommunications Study Commission, Richmond.
PUB DATE 6 Sep 79
NOTE 25p.; For related documents, see IR 008 153 and IR 008 156

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Computers: Electronic Data Processing; *Higher Education: *State Programs: *Telecommunication
IDENTIFIERS *Virginia

ABSTRACT

The use of computers in Virginia's institutions of higher education is reviewed and the role played by data communications in the work of the institutions is discussed. In this paper, data communications is defined to mean the movement of information from one place to another without changing the value of the information. State plans for developing and managing the facilities for data processing in higher education are reviewed, as well as its current use, and some trends indicating future growth in this area are briefly discussed. (RAO)

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Working Paper #15

TELECOMMUNICATIONS STUDY COMMISSION

TELEPROCESSING: USE BY VIRGINIA INSTITUTIONS OF HIGHER EDUCATION

SEPTEMBER 6, 1979

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Introduction

In this working paper the use of computers in Virginia's institution's of higher education is reviewed, and the role played by data communications in the work of the institutions is discussed. As noted in Working Paper #14, higher education has traditionally been considered to be "unique in its computational requirements, as compared with the state agencies. Several reasons for the difference have been given there and elsewhere. In higher education, on the one hand, a large fraction of the computational load is in the instructional and research areas. The work tends to be varied, the programs to be short and used only once or a few times, and the computers to be of a special-purpose nature in many cases. In the state agencies, on the other hand, the work consists mainly of administrative data processing, which is characterized by the repetitive use of relatively fewer and larger programs, operating on large volumes of data through general purpose computers.

Because of the differences in computing requirements, different types of facilities have been developed and different management structures have evolved. Consolidation of data processing operations into a few centers and development of large networks have marked the path followed by the state agencies; the retention and increase of local computing power, mixed with the use of regional networks, has been the plan adopted by higher education.

Definitions

In this paper data communications is defined to mean the movement of information from one place to another without changing the value of the informaiton. There may be code conversions or speed changes, but the content of the message being sent is changed. According to this definition, data communications is distinct from data processing, in which information is operated on with the express purpose of enhancing its value to the user. These concepts and definitions are important in considering the areas of responsibility of the state agencies concerned with the management of data communications and data processing, VPTC (through OGTS) and DMASD.

Review of the State Plans for Educational Data Processing

In this section of the working paper, a brief history is given of the plans for developing and managing the facilities for data processing in higher education. Actually, management by the state has at all times encompassed both the state agencies and higher education, but some important differences have been permitted between the two areas. In Working Paper #14, management of data processing in the state agencies is described; in this paper the emphasis is on higher education.

The earliest important attempt to review the expenditures for data processing in Virginia and to develop controls over the expenditures was the appointment by then Governor Mills E. Godwin, Jr., of a Computer Advisory Committee in March, 1967. That

committee recommended that a detailed study of the state's needs in data processing be made by an outside consulting firm. Touche, Ross, Baily, and Smart was chosen for the work. As a result of the consultant's report, the Virginia Division of Automated Data Processsing (DADP) was established in 1968. It was the predecessor of the present Department of Management Analysis and Systems Development (DMASD) which was established July 1, 1976.

A plan for the statewide development of data processsing was published by the Division of ADP in 1969, but the plan did not provide for the institutions of higher education. They were considered to be different from the state agencies because of their "unique requirements for the support of instruction and research." Subsequently, a companion plan was prepared for higher education under the sponsorship of the State Council for Higher Education, (SCHEV) working together with the Division of ADP. An Advisory Council on Educational Data Processing, a group of nineteen members of the administration and faculty drawn from the institutions of higher education, developed the plan. (This group was much like the present Advisory Council for Educational Computing.) The plan was accepted by the State Council for Higher Education and approved by Governor Godwin in October, 1969. Notable features of the plan were:

1. The creation of three regional centers, at the College of William and Mary, the University of Virginia, and Virginia Polytechnic Institute. The centers were to provide computing and consulting services, wherever possible, to all the institutions of higher education.

Regional boundaries were defined but did not preclude an institution from obtaining services from another regional center. Overall coordination was vested in the Advisory Council on Educational Data Processing and the ADP Systems Administrator. (The position was in SCHEV; it was abolished when DMASD was established.)

2. The need for some local computer equipment was recognized in the plan. All proposals for the acquisition of computers or computer-related equipment at either a regional center or the other institutions had to be approved by the ADP Systems Administrator and the Director of the Division of ADP.
3. The plan included a set of contractual guidelines for establishing operating policies and procedures at the regional centers and for agreements between the centers and the user institutions.
4. In the plan as stated, data communications equipment was considered to be computer-related. In the operation of the plan, however, some data communications equipment, such as communications controllers, came under the control of DADP, whereas other equipment, including transmission facilities and modems, came under the jurisdiction of the Division of Engineering and Buildings.

Although the 1969 plan was the first formal document concerned with sharing computer resources and setting up teleprocessing networks in higher education, such operations had already been in effect at least since 1967. In 1967, the College of William and

Mary was providing services to Christopher Newport College, Richard Bland College, and the Virginia Institute of Marine Science. Similar operations were underway at the University of Virginia and Virginia Polytechnic Institute.

Beginning in 1971, the possibility of a single statewide data network was considered by the directors of the three regional centers, Virginia Commonwealth University, and the State Department of Community Colleges. These discussions resulted in the formation of the Virginia Information Systems Exchange (VISE) in the spring of 1974.

A plan was developed for a multinode network that would make available to every institution of higher education the major computing resources of the entire state. The plan was published in November, 1974, and was approved by the Advisory Council on Educational Data Processing. The State did not adopt the plan.

In 1974, the then Acting Secretary of Education, Carter O. Lowance established a Task Force to develop a master plan for ADP in Higher Education. In addition, an ADP Policy Committee consisting of the presidents of five institutions and the Directors of SCHEV and DMASD were asked to review the plan developed by the Task Force and make recommendations to the Secretary of Education and the Secretary of Administration and Finance. A Master plan was submitted to the ADP Policy Committee for approval in 1976. In its 1976 plan the Task Force endorsed the concepts of the 1969 Plan "as being those most compatible with the traditions, practises, and needs of Virginia's state-supported colleges and universities." However, the 1969 Plan was considered

to be inadequate in some respects, and several amendments were recommended. The main concern was that the 1969 plan no longer previded "responsive, cost-effective computer support for the programs and activities" of the state's institutions with their varied missions. Data communications costs were identified [by the Task Force] as the strongest factor militating against extended use of computer networks for resource sharing." In addition, the Task Force recommended the "development of a cost-effective network permitting cross-linkage of all computing facilities at institutions of higher education be taken as a five-year objective."

An Advisory Council for Educational Computing (ACEC) was established in 1975, replacing the Advisory Council on Educational Data Processing. The ACEC was charged with monitoring the ADP Plan, reviewing budget guidelines, coordinating joint systems development, and overseeing network development and utilization [emphasis added]. The ACEC serves in an advisory capacity to the ADP Policy Committee.

On January 25, 1978, the ACEC recognized in a position statement the importance of regional computer centers in the evolutionary growht of computer support for higher education and recommended "that the concept of resource sharing through regional centers be broadened to include all institutions of higher education and that the term 'Regional Center' be replaced by 'Virginia Educational Computing Network.'"

In April, 1979, the Virginia Plan for Educational Computing was presented to the ADP Policy Committee. It was approved by that Committee in June and later by the General Processional Advisory Committee. The Plan was then sent by the Director of the State Council of Higher Education to the Secretaries of Education and of Administration and Finance for their review and endorsement. According to Mr. Don Miller, Management Informations System (MIS) Director for Education, responses are expected by early September. Should the responses be favorable, the Plan will become operational.

Important points of the proposed Plan are:

1. Virginia's policy concerning automated data processing in institutions of higher education is "to provide responsive, cost-effective computer support for the programs and activities undertaken by each institution in performance of its respective mission."
2. Since computing and data processing are "fundamental to the process of higher education, the plan for development and management of educational computing rightly derives from plans for higher education in general."
3. Statutory responsibility for data processing is vested in the Department of Management Analysis and Systems Development. "MASD's role is interpreted to include a cost-effectiveness review of all proposals for computing services. The conclusions of that review are considered advisory to the proposing institution's chief executive officer, who shall take responsibility for any divergence therefrom."

4. "The question of manageability is particularly important in planning for educational computing, where diversity among institutions, programs, and procedures is not only great, but deliberate."

5. The administrative procedures of the institutions differ so greatly that "proposals for centralization are simplistic at best, and probably impossible to implement. This is true because administrative procedures are largely determined by academic processes. Educational data processing systems are large and complicated and not necessarily the most efficient because they are specifically designed to impose minimum constraints on academic processes. ... The special characteristics and needs of higher education in general, and Virginia institutions in particular, argue strongly for decentralization and the provision of 'locally-owned-and-operated' computing resources."

6. There may be needs, such as the use of simulation programs or other special programs, that cannot be met economically with on-site facilities. Access to a large computer or a specific piece of software may be required, which could be accomplished through a statewide data communications network. "The strongest factor militating against extended use of computer networks for resource sharing is the cost of data communications. ... Thorough economic analysis of the cost of data communications has been complicated by the lack of detailed rates on charges for data transmission." A combination of on-site and

shared computer facilities is considered desirable, and "development of a single network that will permit cross-linkage of all computing facilities at institutions of higher education is taken as a five-year objective. The higher education community will support and rely on the Network Task Force activity recommended in the JOINT REPORT OF THE ADP POLICY COMMITTEE AND THE ADP TASK FORCE FOR HIGHER EDUCATION to develop and implement the network facility."

7. "Changes in technology, in the relative cost of computing and data communications, and in the size and requirements of the various institutions, together with recognition that convenience and timeliness are true economic goods which must be includid in overall considerations of cost-effectiveness, now argue for increasing levels of on-site capacity." Where a large facility, such as that installed at a major research institution, is needed, the integrated network will make access to that facility possible.
8. The "concept of resource sharing through regional centers has been broadened to include all institutions of higher education in the 'Virginia Educational Computing Network' (VECN). The delivery of computing services to institutions of higher education will be facilitated by the Network."
9. "Sufficient on-site capacity will be permitted for administrative and instructional applications. Expanded capabilities for research must be justified in terms of on-site versus Network resources. ... A resource sharing

philosophy will be the standard operating procedure."

10. "Oversight responsibility for the VECN is vested in the ACEC, as provided in the JOINT REPORT OF THE ADP POLICY COMMITTEE AND THE ADP TASK FORCE FOR HIGHER EDUCATION. ... The Council [ACEC] is advisory to the ADP Policy Committee and has responsiblity for monitoring the ADP Plan for Higher Education, review of budgetary guidelines and network pricing policies and rates, review of standards, coordination of system development efforts by user cooperatives, and oversight of networking activities among the institutions."

11. "The ACEC will rely on the Network Task Force activity to develop and implement the network facility. ... Administration of the network facility will be handled according to statutory provision. The main ACEC concern will be the sharing of resources, ... with the goal of providing access for any student or faculty member at any educational institution in the Commonwealth to the computing resources at any other institution."

Finally there is a set of contractual guidelines for use between host institutions and user institutions.

NOTE: The foregoing summary of the Plan is fairly complete, but the points listed have, of course, been taken out of context. It is believed, however, that the summary represents the spirit of the Plan.

COMMENTS: There are several references in the Plan, directly

or indirectly, to the use of data communications. Most obvious is the proposal for a statewide integrated network, in which all the computing facilities in the many institutions could communicate with each other. With the present levels of technology in hardware and software the proposal is feasible, and indeed, such networks exist in some other states, although possibly on a smaller scale. There are also nationwide networks, operated on a commercial basis, and the ARPANET AND EDUNET networks for academic use.

An important question concerns the extent to which a statewide network would be used by higher education and, in consequence, whether or not the benefits of the network would be in proportion to the cost. A more thorough analysis of the projected interinstitutional traffic loads is needed before an answer can be given.

The 1979 Plan refers to the lack of detailed rates on charges for data transmission. There appears to be some confusion on this issue. OGTS does have a schedule of installation charges and monthly charges for each kind of circuit used for data transmission. The schedule is exhibited in Working Paper #14. Confusion seems to exist in the case of a dial-up (voice grade) SCATS line that is used for data transmission. In this case a flat monthly charge is made, based on the cost to the state for the circuit, plus whatever overhead is added by OGTS. The monthly charge is independent of the usage of the circuit; in fact, it covers full-time usage. Incidentally, few of the circuits used for data transmission fall into this category; the vast majority are private lines operating at higher speeds. Perhaps the whole issue of

charging needs further study, or at least clarification, since the rates affect the current use of data communications facilities and ought to be considered when deciding whether or not to install a state wide communications network.

Responsibility for the design and implementation of the network (VECN) has been delegated to the Network Task Force. No mention is made of OGTS, although the Plan does state that "Administration of the network facility will be handled according to statutory provision." Certainly, the management structure needs to be defined, or else it may be vaguely split among the ACEC, DMASD, and OGTS.

Current Use of Teleprocessing in Higher Education in Virginia

Information has been collected from all the large institutions and from several of the smaller ones in Virginia concerning their use of teleprocessing. Briefly, most of the institutions have an on-campus network, usually for providing interactive computing services; a few are serving one or more other institutions, for interactive computing and remote batch work. Hewlett-Packard computers have been installed in many of the institutions; much of the interactive computing appears to be performed on them. There are, however, a large Honeywell system at VPI & SU and a DEC system at ODU, both of which are used for interactive computing. Medium to large-scale general purpose computers have been installed at the University of Virginia, the VCU-VCCS Center, Old Dominion University, and William and Mary. Other institutions use these facilities for performing computations that cannot be done on

their own systems; running large simulation programs is one example. There is no statewide network. Most of the network development has been clustered around five large systems. Some software has been written to permit communication between different computers, but not all computers and terminals can communicate with each other. The problem is that the computer vendors represent generally non-overlapping subsets of popular communications protocols.

In the following paragraphs a short description is given of the computer hardware at each of several institutions, along with the extent to which teleprocessing is used.

The University of Virginia has three computer systems in their Academic Computing area: two Hewlett-Packard systems and a Control Data Cyber 172. A sophisticated arrangement of multiplexors, a Gandalf port selector, and other communications gear allow for both dial-up and hardwired terminals, at transmission rates of 10 characters per second up to 9600 bits per second, to access the computers. In addition to serving local terminals, the computers can be accessed via multiplexers at VPI&SU, Clinch Valley College, Longwood College, Virginia Military Institute, and the University of Richmond. The teleprocessing system was designed by personnel at UVa. Approval for communications processors was obtained from DMASD and for installation of transmission circuits from OGTS.

VPI&SU also provides access to their computer systems to both off and on-line campus users. The computers are two IBM

370/158's and a Honeywell 68/60. The Honeywell machine is operated under a special time-sharing system, MULTICS. Again, a sophisticated system of multiplexors and data switches permits users to have access to the machines from a variety of terminal types and speeds. The teleprocessing system was designed by VPI&SU personnel, but approval for the equipment was obtained from DMASD and OGTS.

Virginia Commonwealth University and the Virginia Community College System jointly operate a computing system and teleprocessing network, located on the VCU campus. The network serves VCU and 23 community colleges over both dedicated and dial-up lines. The computers are an IBM 370/158 and an IBM 370/148. Network processing takes place through IBM and Memorex communications controllers.

Virginia Military Institute has a Burroughs B6800 computer and 32 terminals ranging in speed from 300 to 9600 bits per second. SCATS lines are used for both voice and data communications; several lines also permit data communications with the center at UVa.

At the College of William and Mary an IBM 370/158 serves both on-campus and remote users. A variety of line speeds for interactive and batch use is available. Simple multiplexing equipment and a transmission control unit are used.

Old Dominion University has a DEC-10, which is heavily used for on-campus interactive computing as well as local batch work. The University has approximately 130 hardwired lines, operating at speeds of 110 to 2400 bits per second.

A Gandalf port selector has 160 input lines and 80 output lines going to the DEC-10 computer. Microcomputers have been installed for individual departmental use. Large statistical programs are transmitted to the center at William and Mary for processing there.

Christopher Newport College and Norfolk State University have Hewlett-Packard computers. The machines serve on-campus terminals; they can also communicate with the computers at William and Mary and the University of Virginia.

James Madison University has two Hewlett-Packard systems. They serve the academic and administrative users through dedicated and dial-up lines. One of the machines has the facilities needed to communicate with UVA and VPI&SU.

George Mason University also operates two Hewlett-Packard computers. Besides serving on-campus terminals, they can be used as remote stations for connection to UV and William and Mary.

Mary Washington College has one Hewlett-Packard computer. At present it is used only for on-campus purposes through dial-up lines.

At Virginia State University, several keyboard terminals and CRT display units serve on-campus users. The total number of terminals is about 45. An IBM 370/135 computer is installed at the University.

Teleprocessing Requirements

As indicated in the foregoing list of computer facilities

in higher education, teleprocessing is being heavily used with on-campus terminals and, to a considerable extent, for communications over greater distances. Some idea of the requirements can be gotten from looking at typical terminals and their speeds, as listed in the following table:

Terminal Type	Line Speed, Bits/Second
Low-Speed keyboard/typewriter Teletype, IBM 2741, etc.	Up to 134
Medium-Speed keyboard/typewriter Many brands @ 30-60 chars./sec.	300-600
Asynchronous CRT display 120 chars./sec.	1,200
Low-Speed printers 120 chars./sec.	1,200
Graphics display Tektronix, etc.	1,200-9,600
High-Speed CRT's IBM 3277, etc.	9,600
Remote card reader/printer units	4,800-9,600

The table shows the wide range of line speeds needed to accommodate currently installed terminals. It is safe to predict that the number of high-speed terminals will increase, certainly the CRT's and those used for graphics.

Trends

The most obvious trend in computing for higher education in Virginia is the high rate of growth in the use of computers. Fifteen years ago, only the largest and most research-oriented colleges had a programmable computer. In the period from 1965-70 several schools acquired machines, and some sharing of

resources through minor networks took place. In the present decade the pace has accelerated; the availability of large and fast machines, along with mini- and microcomputers, all at decreasing costs per computation, has put at least some machine within the budget of every institution. Demand has also increased dramatically, in each of the areas of instructional, research, and administrative uses.

Probably the greatest change has been in the character of computing. In the earliest days, practically all jobs were run in a sequential batch mode. The turn-around time --- the length of time between when a user submits a job and when he receives the computer output --- was typically in the range of several minutes to a few hours. During the early and middle 1970's the hardware and software for interactive computing became generally available. It gave almost immediate access to the computer and often cut the time to write and debug a program by at least a factor of two; consequently, users demanded to have it. Now there are hundreds of interactive terminals in use in Virginia. They range from 10 character-per-second keyboard terminals to high speed cathode-ray-tube display units.

The proliferation of terminals has caused a corresponding need for increased communications capabilities. In place of the early stand-alone computer, there are now computers serving as many as a few hundred terminal devices each, all through communications equipment and lines. Computers and communications equipment, while definably distinct, are needed in combination in virtually all computing installations.

The improvements in the technology of computers, such as miniaturization of components and large-scale integration have drastically cut the cost of the machines. Since 1970, on a per-computation basis, the cost has been cut by about a factor of ten (obtained by comparing the prices and speeds of IBM System 360 machines with those of IBM 43xx's). Software and personnel costs have increased, however, and communication costs, at least in Virginia, have just about doubled.

It is difficult to assess the overall effect of the changes in cost. There has probably been a net decrease in the cost per computation, but because of an increased use of computers, institutional computing budgets have steadily risen.

There is a trend toward dedicated, special-purpose computer systems. These systems support terminals, but the terminals are usually installed on the same campus as the computer. Consequently, communications costs are low; this has often been used as one of the arguments for obtaining the systems.

The trend is likely to continue, with further decentralization, into the departmental level within a school. For as little as $3,000 a department can purchase a microcomputer that can be programmed in BASIC, or for $30,000 a small minicomputer that can be programmed in several languages and can also communicate with a large computer. Not only do instructional departments find these machines useful as teaching tools, but a business office can, for example, do some of its accounting locally and then access large files on another computer.

Management of Teleprocessing Higher Education

The management of teleprocessing in higher education at the state level may best be seen as a part of the whole management structure of computing activities and data communications. The following table lists the offices involved and their authority:

1. MIS Director of Education, Office of the Secretary of Education

   Gives preliminary approval to all proposals for changes in computing facilities and personnel. Also responsible for developing plans for computing in higher education.

2. Director, DMASD

   Approves proposals for changes in computing facilities or personnel.

3. Director, OGTS

   Approves proposals for acquisition of communications equipment and services.

The role of the Director of OGTS in the management of teleprocessing is not completely clear; there are a few areas where his responsibilities have been delegated to other groups or agencies when those agencies have prepared acceptable master plans.

According to the Master Plan for Telecommunications, Chapter VIII, OGTS has, among its responsibilities, that of analyzing, reviewing, and approving "all specifications for interconnective telecommunications facilities and network interval devices to be requisitioned by any Commonwealth organ,

agency or institution... . Computers and other data processing equipment per se should be exempted since these technical terms are already subject to control by DMASD." In regard to computers, OGTS has the responsibility "to advise DCS on matters relating to the efficient and expeditious network interconnection of computers with other computers or with terminals. (Modems, multiplexers, concentrators and similar device systems are to be regarded as OGTS-governed network facilities)."

The last-mentioned area, that of multiplexers and concentrators, as well as that of sophisticated front-end communications processors, is perhaps a gray area in data communications. The front-end processors are often supplied by a computer manufacturer, is programmable, and is acquired as part of a total computing system. The communications aspect is frequently regarded as extending from modem to modem along the transmission line. Consequently, DMASD has sometimes exercised approval authority over equipment which may come under OGTS.

A more serious problem is that concerned with the responsibility of OGTS to be "visibly accessible, expert, responsive and expeditious in helping the various Commonwealth agencies, institutions and organs to solve their critical communications problems through imaginative, coordinated and well-managed datacommunications arrangements and processes." In this case, OGTS does not have the manpower required to fulfill its mandated responsibility. As noted earlier in this paper, in the descriptions of the network facilities at the institutions of higher

education, OGTS approved the equipment that was acquired but was not involved to a major degree in the design of the facilities.

The reasons for this problem lie in (1) a lack of manpower, as noted, and (2) in the strong growth in the use of data communications since the Master Plan was written. No one, in 1974, could have envisioned the rapid changes that have since taken place in computer technology and, particularly, the great increase in interactive computing.

The solution to the problem may not be simple. If the state is to define clear areas of responsibility, then there will have to be unambiguous definitions of computers and data communications equipment. Further, the state will have to create a group of technical personnel who are expert in many phases of teleprocessing.

The Future of Teleprocessing in Higher Education

Much has already been said in this paper about the rapid growth in the use of data communications by higher education. It would be helpful to know where we stand, at present, on the growth curve. Obviously, we can only make an estimate.

One possible basis for estimating is the extent to which computing is now being used in the schools and the extent to which it might be used. At present, computers are used in the administrative offices, in research, and in several areas of instruction, with the heaviest use normally in the physical sciences. Schools of business administration, education, and law also may be major users of computing services. Beginnings

have been made in computer-assisted instruction and the use of graphics terminals. If there are continued improvements in the hardware technology and the programming, as can be expected, then the demand for these capabilities will quickly follow. The demand could be substantial.

The proposed statewide network has been mentioned and discussed slightly. There are obvious benefits to be gained from the network; the ability to access programs and data resident on a computer in another institution and the use of load-sharing are examples. There remain, however, questions about the design, cost, extent of use, and management of the network, insofar as higher education is concerned.

Whether or not the proposed network is installed, the use of teleprocessing in higher education can be expected to increase and possibly the modes of transmission will change; and the use of nationwide networks, such as EDUNET, will grow.

Conclusions

The following conclusions have been reached, based on the data gathered during the preparation of this working paper:

1. The proposed statewide network would have functional benefits for higher education, such as permitting a more effective sharing of resources, but the extent to which the network would be used has not been accurately determined. Consequently, it is not clear that the network can be justified at this time.
2. There is a rapidly increasing use of interactive

computing in higher education; this trend is likely to continue. Additional communication facilities will be needed.

3. Costs of software, personnel and data communications have steadily increased, whereas the cost of computer hardware has been decreasing.
4. OGTS has legal authority to approve the acquisition of all data communications equipment in the institutions of higher education. In practice however, the planning for the data communications systems has been done by personnel at the institutions although this is a mandated function of OGTS. If the state is to do this work, it must develop a technical staff.
5. Long range, statewide planning for the use of data communications, including considerations of changes in technology appears to be non-existent. Again, if the state is to perform this function, a technical staff must be developed.